

WHAT IS CLAIMED IS:

1. An apparatus for calculating an intermediate value between a first value, X, and a second value, Y, as $P * X + (1 - P) * Y$ where P is a non-zero, non-unitary fraction value with an odd number denominator, said apparatus comprising:

a combined multiplication stage including a plurality of multiplexing devices, each having inputs to receive said first and second values, and each having a select input to receive a bit signal from a binary representation based on a numerator of said fraction value multiplied by a constant, c, and an adder coupled to outputs of said multiplexing devices.

2. The apparatus of claim 1 further comprising a division stage coupled to said combined multiplication stage to generate said intermediate value.

3. The apparatus of claim 1 wherein said combined multiplication stage includes an incrementing device producing an output that is an input incremented by one.

4. The apparatus of claim 3 wherein said combined multiplication stage includes a set of mux shifting devices, each having an input and an output, and each used for multiplying at least one of said first value and said second value by a base 2 number.

5. The apparatus of claim 4 wherein c equals (2^d minus one) divided by said denominator, an integer d is such that said denominator divides (2^d minus one) , and an integer m is such that m is a smallest integer where $2^m \geq (n \text{ plus } d) \text{ divided by } d$.

6. The apparatus of claim 5 wherein said combined multiplication stage includes:

(1 to d) multiplexing devices;

said incrementing device incrementing by one said output of said (d)th multiplexing device;

(1 to d - 1) mux shifting devices where said output of said 1st mux shifting device is said output of said 2nd multiplexing device shifted to the left one place and continuing in this manner, said output of said (d - 2)th mux shifting device is said output of

said (d - 1)th multiplexing device shifted to the left (d - 2) places and finally, said output of said (d - 1)th mux shifting device is said output of said incrementing device shifted to the left (d - 1) places; and

said adder having (1 to d) inputs to receive said outputs of said (1 to d - 1) mux shifting devices and said output of said 1st multiplexing device.

7. An apparatus for calculating an intermediate value between a first value, X, and a second value, Y, as $P * X + (1 - P) * Y$ where P is a non-zero, non-unitary fraction value with an odd number denominator, said apparatus comprising:

a division stage including a set of result adding devices, connected in series, each having an input and an output, each of said result adding devices generating an output value that is more precise than its input value.

8. The apparatus of claim 7 further comprising a combined multiplication stage coupled to said division stage to generate said intermediate value.

9. The apparatus of claim 8 wherein said division stage includes a set of add shifting devices, each used for multiplying an input by a base 2 number producing an output.

10. The apparatus of claim 9 wherein c equals (2^d minus one) divided by said denominator, an integer d is such that said denominator divides (2^d minus one) , and an integer m is such that m is a smallest integer where $2^m \geq (n \text{ plus } d)$ divided by d.

11. The apparatus of claim 10 wherein said division stage includes:

(1 to m) add shifting devices;

(1 to m) result adding devices where said output of said 1st result adding device is the addition of an output from an adder from said combined multiplication stage and that output shifted (d) places to the left by said 1st add shifting device, and if m is greater than 1, then said output of said 2nd result adding device is the addition of said output from said 1st result adding device and that output shifted $(2 * d)$ places to the left by said 2nd add shifting device and continuing in this manner until said output of said (m)th result adding device is the

9 addition of said output of said (m - 1)th result adding device and that output shifted ($2^{m-1} * d$)
10 places to the left by said (m)th add shifting device; and
11 a result shifting device used for shifting said output from said (m)th result
12 adding device to the right by ($2^m * d$) places producing said intermediate value.

1 12. An apparatus for multiplying a value, X, by a fraction, P, producing a result, where P
2 is a non-zero, non-unitary fraction value with an odd number denominator, said apparatus
3 comprising:

4 a combined multiplication stage including a plurality of ANDing devices, each having
5 inputs to receive said value and a setting input to receive a bit signal from a binary
6 representation based on a numerator of said fraction value multiplied by a constant, c, and an
7 adder coupled to outputs of said ANDing devices.

1 13. The apparatus of claim 12 further comprising a division stage coupled to said
2 combined multiplication stage to generate said result.

1 14. The apparatus of claim 12 wherein said combined multiplication stage includes an
2 incrementing device to produce an output that is an input incremented by one.

1 15. The apparatus of claim 14 wherein said combined multiplication stage includes a set
2 of AND shifting devices, each having an input and an output, and each used for multiplying
3 said value by a base 2 number.

1 16. The apparatus of claim 15 wherein c equals (2^d minus one) divided by said
2 denominator, an integer d is such that said denominator divides (2^d minus one), and an integer
3 m is such that m is a smallest integer where $2^m \geq (n \text{ plus } d)$ divided by d.

1 17. The apparatus of claim 16 wherein said combined multiplication stage includes:
2 (1 to d) ANDing devices;
3 said incrementing device incrementing by one said output of said (d)th
4 ANDing device; and

(1 to d - 1) AND shifting devices where said output of said 1st AND shifting device is said output of said 2nd ANDing device shifted to the left one place and continuing in this manner, said output of said (d - 2)th AND shifting device is said output of said (d - 1)th ANDing device shifted to the left (d - 2) places and finally, said output of said (d - 1)th AND shifting device is said output of said incrementing device shifted to the left (d - 1) places; and said adder having (1 to d) inputs to receive said outputs of said (1 to d - 1) AND shifting devices and said output of said 1st ANDing device.

18. An apparatus for multiplying a value, X, by a fraction, P, producing a result, where P is a non-zero, non-unitary fraction value with an odd number denominator, said apparatus comprising:

a division stage including a set of result adding devices, connected in series, each having an input and an output, each of said result adding devices generating an output value that is more precise than its input value.

19. The apparatus of claim 19 further comprising a combined multiplication stage coupled to said division stage to generate said result.

20. The apparatus of claim 18 wherein said division stage includes a set of add shifting devices, each used for multiplying an input by a base 2 number producing an output.

21. The apparatus of claim 20 wherein c equals (2^d minus one) divided by said denominator, an integer d is such that said denominator divides (2^d minus one) , and an integer m is such that m is a smallest integer where $2^m \geq (n \text{ plus } d) \text{ divided by } d$.

22. The apparatus of claim 21 wherein said division stage includes:

(1 to m) add shifting devices;

(1 to m) result adding devices where said output of said 1st result adding device is the addition of an output from an adder from said combined multiplication stage and that output shifted (d) places to the left by said 1st add shifting device, and if m is greater than 1, then said output of said 2nd result adding device is the addition of said output from said 1st

7 result adding device and that output shifted ($2 * d$) places to the left by said 2nd add shifting
 8 device and continuing in this manner until said output of said (m)th result adding device is the
 9 addition of said output of said (m - 1)th result adding device and that output shifted ($2^{m-1} * d$)
 10 places to the left by said (m)th add shifting device; and
 11 a result shifting device used for shifting said output from said (m)th result
 12 adding device to the right by ($2^m * d$) places producing said intermediate value.

1 23. A method for calculating an intermediate value between a first value, X, and a second
 2 value, Y, as $P * X + (1 - P) * Y$ where P is a non-zero, non-unitary fraction value with an odd
 3 number denominator, said method comprising:

4 finding a smallest integer d such that (2^d minus one) divided by said denominator is a
 5 whole number;

6 calculating a number c such that c equals (2^d minus one) divided by said denominator;

7 finding an integer m such that m is a smallest whole number where $2^m \geq (n \text{ plus } d)$
 8 divided by d;

9 calculating an initial result S_0 which equals c multiplied by a numerator multiplied by
 10 said first value plus c multiplied by (said denominator minus said numerator) multiplied by
 11 said second value plus 2^{d-1} ;

12 calculating (1 to m) S_{i+1} where i equals 0 to (m minus 1) and $S_{i+1} = S_i$ plus S_i shifted to
 13 the left by (d multiplied by 2^i) places; and

14 shifting S_m to the right by (d times 2^m) places resulting in said intermediate value.

1 24. The method of claim 23 wherein said initial result S_0 has (d) ones in a first binary
 2 representation of c multiplied by said numerator and in a second binary representation of c
 3 multiplied by (said denominator minus said numerator) and said first binary representation
 4 and said second binary representation are an inverse of each other.

1 25. A method for multiplying a value, X, by a fraction, P, producing a result, where P is a
 2 non-zero, non-unitary fraction value with an odd number denominator, comprising:

3 finding a smallest integer d such that (2^d minus one) divided by said denominator is a
 4 whole number;

calculating a number c such that c equals (2^d minus one) divided by said denominator;
finding an integer m such that m is a smallest whole number where $2^m \geq (n \text{ plus } d)$
divided by d ;
calculating an initial result S_0 which equals c multiplied by a numerator multiplied by
said value plus 2^{d-1} ;
calculating $(1 \text{ to } m) S_{i+1}$ where i equals 0 to $(m \text{ minus } 1)$ and $S_{i+1} = S_i$ plus S_i shifted to
the left by $(d \text{ multiplied by } 2^i)$ places; and
shifting S_m to the right by $(d \text{ times } 2^m)$ places producing said result.

26. The method of claim 25 wherein said initial result S_0 has at most (d) ones in a binary
representation of c multiplied by said numerator.

27. A computer system comprising:

a processor,
a bus connected to said processor,
a graphics controller connected to said bus, said graphics controller
comprising:
an apparatus for calculating an intermediate value between a first value,
 X , and a second value, Y , as $P * X + (1 - P) * Y$ where P is a non-zero, non-unitary fraction
value with an odd number denominator, said apparatus comprising:
a combined multiplication stage including a plurality of
multiplexing devices, each having inputs to receive said first and second values, and each
having a select input to receive a bit signal from a binary representation based on a numerator
of said fraction value multiplied by a constant, c , and an adder coupled to outputs of said
multiplexing devices; and
a display device for displaying output from said graphics controller.

28. A computer system comprising:

a processor,
a bus connected to said processor,

4 a graphics controller connected to said bus, said graphics controller
5 comprising:
6 an apparatus for calculating an intermediate value between a first value,
7 X, and a second value, Y, as $P * X + (1 - P) * Y$ where P is a non-zero, non-unitary fraction
8 value with an odd number denominator, said apparatus comprising:
9 a division stage including a set of result adding devices,
10 connected in series, each having an input and an output, each of said result adding devices
11 generating an output value that is more precise than its input value; and
12 a display device for displaying output from said graphics controller.

1 29. A computer system comprising:

2 a processor,
3 a bus connected to said processor,
4 a graphics controller connected to said bus, said graphics controller
5 comprising:
6 an apparatus for multiplying a value, X, by a fraction, P, producing a
7 result, where P is a non-zero, non-unitary fraction value with an odd number denominator,
8 said apparatus comprising:
9 a combined multiplication stage including a plurality of
10 ANDing devices, each having inputs to receive said value and a setting input to receive a bit
11 signal from a binary representation based on a numerator of said fraction value multiplied by a
12 constant, c, and an adder coupled to outputs of said ANDing devices; and
13 a display device for displaying output from said graphics controller.

1 30. A computer system comprising:

2 a processor,
3 a bus connected to said processor,
4 a graphics controller connected to said bus, said graphics controller
5 comprising:

an apparatus for multiplying a value, X, by a fraction, P, producing a result, where P is a non-zero, non-unitary fraction value with an odd number denominator, said apparatus comprising:

a division stage including a plurality of result adding devices, connected in series, each having an input and an output, each of said result adding devices generating an output value that is more precise than its input value; and

a display device for displaying output from said graphics controller.